

CLAIMS:

1. A continuous method of recycling a metal/organic laminate comprising metal laminated with an organic material, the method comprising:

providing a reactor comprising a first chamber containing a first bed of particulate microwave absorbing material and a first rotary stirrer, and a second chamber containing a second bed of particulate microwave absorbing material and a second rotary stirrer, the second chamber having an exit from the reactor;

introducing laminate and additional particulate microwave absorbing material into the first chamber containing the first bed of particulate microwave absorbing material;

stirring the particulate microwave absorbing material and laminate in the first chamber using the first rotary stirrer and applying microwave energy to the mixture of particulate microwave absorbing material and laminate in the first chamber to heat the particulate microwave absorbing material in the mixture to a temperature sufficient to pyrolyse organic material in the laminate;

transferring a portion of the mixture in the first chamber to the second chamber containing the second bed of particulate microwave absorbing material;

stirring the mixture in the second chamber using the second rotary stirrer and applying microwave energy to the mixture in the second chamber to heat the particulate microwave absorbing material in the mixture to a temperature sufficient to pyrolyse organic material remaining in the laminate, whereby laminate or delaminated metal migrates towards and floats on the upper surface of the mixture in the second chamber, said second rotary stirrer rotating in a horizontal plane and being so configured as to fluidise the mixture such that the upper surface of the fluidised mixture has a radial profile that biases laminate or delaminated metal floating on the fluidised mixture to migrate radially outwards;

transferring a portion of the mixture in the second chamber to the exit from the reactor; and

recovering metal from the exit from the reactor.

2. A method according to claim 1 wherein the transfer of the portion of the mixture in the first chamber to the second chamber is via one or more intermediate chambers

each containing a bed of particulate microwave absorbing material stirred by a rotary stirrer.

3. A method according to claim 1 wherein the reactor consists of two reaction chambers.
4. A method according to any preceding claim further comprising recovering pyrolysed products from the reactor.
5. A method according to any preceding claim wherein the organic material comprises plastic or paper material, or both.
6. A method according to any preceding claim wherein the particulate microwave absorbing material is heated to a temperature in the range from 500 to 600°C.
7. A method according to any preceding claim wherein the particulate microwave absorbing material is carbon black powder.
8. A method according to any preceding claim further comprising providing an inert or reducing atmosphere in the reactor.
9. A method according to any preceding claim wherein the atmosphere is nitrogen gas.
10. A method according to any preceding claim wherein the additional particulate microwave absorbing material is mixed with the laminate before entering the reactor.
11. A method according to any preceding claim wherein the additional particulate microwave absorbing material or the laminate, or both, is preheated before entering the reactor.
12. A method according to any preceding claim wherein particulate microwave absorbing material is preheated in the reactor before mixing with the laminate.

13. A method according to any preceding claim wherein the action of the stirrer in the first chamber transfers particulate microwave absorbing material from the first chamber to the next chamber.
14. A method according to any preceding claim wherein a portion of the particulate microwave absorbing material in the second chamber exits from the reactor with the metal.
15. A method according to claim 14 further comprising separating the exited particulate microwave absorbing material from the exited metal, and recycling the separated particulate microwave absorbing material to the reactor.
16. A method according to any preceding claim wherein the rotary stirrers describe overlapping paths whereby the action of the rotary stirrers transfers a portion of the particulate microwave absorbing material from the first chamber to the next chamber.
17. A method according to any preceding claim wherein the exit is through a sidewall of the second chamber, and has a bottom surface disposed at a height at or close to the level of the top of the bed in said chamber, such that the metal, and optionally a portion of the particulate microwave absorbing material, exits when its level exceeds the height of said bottom surface.
18. A method according to any preceding claim wherein at least the rotary stirrer in the second chamber is configured as a horizontally extending blade rotating about a vertical axis at its midpoint, the upper edge or upper surface of the blade sloping down from said midpoint towards the extremities of the blade.
19. A method according to claim 18 wherein at least the rotary stirrer in the second chamber is configured as a trapezoidal blade rotating about its midpoint.
20. A method according to any preceding claim wherein the metal/organic laminate comprises aluminium laminated with an organic material.

21. A reactor for recycling a metal/organic laminate comprising metal laminated with an organic material, comprising:

a first chamber containing a first bed of particulate microwave absorbing material and a first rotary stirrer;

a second chamber containing a second bed of particulate microwave absorbing material and a second rotary stirrer, the second chamber having an exit from the reactor;

means for introducing laminate and additional particulate microwave absorbing material into the first chamber containing the first bed of particulate microwave absorbing material;

means for transferring a portion of the mixture in the first chamber to the second chamber containing the second bed of particulate microwave absorbing material;

means for applying microwave energy to the mixture of particulate microwave absorbing material and laminate in the first and second chambers to heat the particulate microwave absorbing material in the mixture to a temperature sufficient to pyrolyse organic material in the laminate;

means for transferring a portion of the mixture in the second chamber to the exit from the reactor; and

means for recovering metal from the exit from the reactor,

wherein said second rotary stirrer rotates in a horizontal plane and is so configured as to fluidise the mixture such that the upper surface of the fluidised mixture has a radial profile that biases laminate or delaminated metal floating on the fluidised mixture to migrate radially outwards.

22. A reactor according to claim 21 further comprising one or more chambers intermediate the first and second chambers, each containing a bed of particulate microwave absorbing material stirred by a rotary stirrer.

23. A reactor according to claim 21 consisting of two reaction chambers.

24. A reactor according to any one of claims 21 to 23 wherein the particulate microwave absorbing material is carbon black powder or activated carbon powder.

25. A reactor according to any one of claims 21 to 24 further comprising an inert or reducing atmosphere in the reactor.
26. A reactor according to claim 25 wherein the atmosphere is nitrogen gas.
27. A reactor according to any one of claims 21 to 26 wherein the stirrer in the first chamber transfers a portion of the mixture in the first chamber to the next chamber.
28. A reactor according to any one of claims 21 to 27 further comprising means for separating the exited particulate microwave absorbing material from the exited metal, and for recycling the separated particulate microwave absorbing material to the reactor.
29. A reactor according to any one of claims 21 to 28 wherein the rotary stirrers describe overlapping paths whereby the action of the rotary stirrers transfers a portion of the particulate microwave absorbing material from the first chamber to the next chamber.
30. A reactor according to any one of claims 21 to 29 wherein the exit is through a sidewall of the second chamber, and has a bottom surface disposed at a height at or close to the level of the top of the bed in said chamber, such that the metal, and optionally a portion of the particulate microwave absorbing material, exits when its level exceeds the height of said bottom surface.
31. A reactor according to any one of claims 21 to 29 wherein at least the rotary stirrer in the second chamber is configured as a horizontally extending blade rotating about a vertical axis at its midpoint, the upper edge or upper surface of the blade sloping down from said midpoint towards the extremities of the blade.
32. A reactor according to claim 31 wherein at least the rotary stirrer in the second chamber is configured as a trapezoidal blade rotating about its midpoint.
33. A reactor according to any one of claims 21 to 32 wherein the metal/organic laminate comprises aluminium laminated with an organic material.